Gaming Elements and Educational Data Analysis in the Learning Design of the Flipped Classroom

Triantafyllou, Evangelia

Publication date:
2019

Document Version
Publisher's PDF, also known as Version of record

Evangelia Triantafyllou (Ed.)

Gaming Elements and Educational Data Analysis in the Learning Design of the Flipped Classroom

AALBORG UNIVERSITY PRESS

Gaming Elements and Educational Data Analysis
in the Learning Design of the Flipped Classroom
Evangelia Triantafyllou (Ed.)

1. Open Access Edition

Layout: Toptryk Grafisk ApS / Grethe Zeuner

ISBN: 978-87-7210-267-2

This book is financially supported by The Section of Medialogy, Department of Architecture, Design and Media Technology, Aalborg University

Published by Aalborg University Press | forlag.aau.dk

PEER
REVIEWED

Preface to the Proceedings of the 1st Workshop on Gaming Elements and Educational Data Analysis in the Learning Design of the Flipped Classroom (GALE)

In recent years, educational institutions have face the pressure of finding new ways to ensure their students' engagement and autonomy in learning, as well as learning outcomes which also incorporates 21st century soft skills. This tendency has led to a paradigm shift from passive listening to active learning. Within that context, the development of the flipped classroom, which inverts the pre- and in-class sessions, is possibly one of the most emblematic endeavours to overhaul educational practices. Interest for the flipped classroom rose sharply in the early 2010s, and research in the field has revealed various and very different designs and implementations of FCs. Moreover, various learning environments and tools have been employed to support such classes.

The GALE workshop was hosted by the 14th European Conference on Technology Enhanced Learning (EC-TEL) 2019. The aim of the GALE workshop was to gather and discuss evidence on different designs and implementations of flipped classrooms, with a focus on cases that incorporated gaming elements or learning analytics in flipped classrooms. The workshop employed a series of diverse and inspiring exercises, making use of different interaction modes to engage the participants in discussions on topics related various aspects of the flipped instruction model. Moreover, the workshop invited authors to submit research papers on related topics.

This book presents the selected papers after a vigorous double-blind review process. I am grateful to the EC-TEL 2019 organizers for their support, and I appreciate the work of all the workshop program committee members in reviewing and selecting the papers. I also thank the authors for their contributions.

Last but not the least, I thank the section of Medialogy, Department of Architecture Design and Media Technology, Aalborg University for its financial support to compile this book.

August 2019

Evangelia Triantafyllou, Assistant Professor
Aalborg University, Copenhagen, Denmark
E-mail: evt@create.aau.dk

Merging flipped learning approaches and learning with ePortfolios in secondary mathematics education

Robert Weinhandl[1], Stefanie Schallert[1], Zsolt Lavicza[1]

[1]Johannes Kepler University Linz, Austria,
robert.weinhandl@gmail.com;
stefanieschallert@gmail.com; lavicza@gmail.com

Abstract

Combining ePortfolios and flipped learning approaches in mathematics education could contribute to ensuring that mathematics education better meets students' current and future needs of their learning and working world. Our study aims to identify how mathematics education should be designed to facilitate combining ePortfolios and flipped learning approaches. To explore these design elements, we conducted a seven-month educational experiment with two secondary classes. Analysing the collected data following design-based research and grounded theory approaches indicate that for students the following categories are central when combining ePortfolios and flipped learning approaches in mathematics education: (a) task communication and task design, (b) intensity of learning, (c) storage and sharing of knowledge, and (d) usability of the learning environment.

Keywords: flipped learning, ePortfolio, mathematics education, student-driven education

1. Introduction

Flipped classroom (FC) approaches in education have gained popularity recently (O'Flaherty & Phillips, 2015). This increased popularity is especially true for mathematics and science education (Muir & Geiger, 2016). In addition to a grown reputation of FC approaches, Esperanza, Fabian, & Toto (2016) could demonstrate that mathematics education following FC approaches could have positive impacts on students' performances and attitudes towards mathematics. Despite the growing popularity of FC approaches in education and the potential positive effects of FC education, there is still no uniform definition of FC education (Wolff & Chan, 2016). Similarly interesting is that despite the short history of FC education, there is already a further development of this approach – namely flipped learning (FL). A distinct contrast between FL and FC education is that FL approaches distinguish mainly between education in group and individual learning spaces (Flipped Learning Network, 2014). Whereas concerning FC approaches, many experts (e.g. Enfield, 2016; Wasserman, Quint, Norris, & Carr, 2015) distinguish between education in pre-class and in-class phases.

Emphasising learning activities and social forms of learning (i.e. individual work, partner work or group work) in FL approaches should facilitate to integrate promising approaches such as dealing with problems meaningful to students (Gainsburg, 2008; Hodges & Hodge, 2017) and creating concrete learning artefacts (Lee & Johnston-Wilder, 2013) into mathematics education. Tackling problems meaningful to students and the associated creation of concrete learning artefacts in mathematics education could also make it appropriate to integrate modern technologies into mathematics education. The educational technologies we have used in our education experiment are GeoGebra (mathematics software) and Mahara (ePortfolio software). Our educational experiment aimed to discover how to synthesise FL approaches and learning with ePortfolios in secondary mathematics education.

To be able to classify our educational experiment scientifically, we focus in the theoretical background on the transition from FC approaches to FL approaches with a particular focus on mathematics education as well as on benefits of ePortfolios in mathematics education. Then, in the section Methods, we discuss the particularities of our educational experiment and how and grounded theory approaches should contribute to achieving our research goal. The section Results illustrates how we have elaborated the core categories (a) task communication and task design, (b) intensity of learning, (c) storage and sharing of knowledge, and (d) usability of the learning environment, and what the particularities of these core categories are. In the final section, we present to what extent our educational experiment has strengthened the existing body of knowledge and what implications our study could have for mathematics education.

2. Theoretical background

To explore a synthesis of FL approaches and ePortfolio work in mathematics education at a secondary level, we present in this section flipped education as well as education in which ePortfolios are used with an emphasis on mathematics education each. In investigating flipped education, we illustrate the transition from FC approaches to FL approaches and elaborate the peculiarities of each approach, taking into account the characteristics of mathematics education. The paragraph dealing with ePortfolio work in education focuses on mathematics, and opportunities and challenges that may arise for teachers and students.

2.1. From FC education to FL education when teaching and learning mathematics

Although there is no uniform definition of FC approaches in education (Wolff & Chan, 2016), a common standard could be deduced from most definitions. According to many experts (e.g. Enfield, 2016; Wasserman et al., 2015), it is a characteristic of FC education that passive learning activities take place outside a classroom. Then, classroom time gained should be filled by student-driven approaches and by students constructing their competencies. Consequently, according to Krathwohl (2002), when education follows FC approaches, lower learning goals should be pursued outside a class and higher learning goals should be tackled in class.

According to the Flipped Learning Network (2014), education bearing FL approaches in mind could be interpreted as a further development of FC approaches. However, it should be considered that teaching following FC approaches does not automatically lead to teaching following FL approaches. According to the descriptions of the Flipped Learning Network (2014), the characteristic features of education following FL approaches are that there is a focus on group and individual learning spaces, and the four pillars of flipped learning: a flexible environment, a new learning culture, an intentional content and a professional educator.

If the particularities of education following FL approaches are applied to mathematics education, it could be seen that mathematics education and education following FL approaches have many similarities or could complement each other. A flexible environment based on FL approaches or students' ability to decide when and how to learn could help to increase students' self-efficacy and confidence. According to Burton (2004) and Chao, Chen, Star, & Dede (2016), it is self-efficacy and confidence that could be decisive for students and student performance in mathematics education. The flexible environment typical for FL approaches, and the new learning culture and intentional content could also reduce anxiety in learning. According to Hung, Huang, & Hwang (2014) and Lee & Johnston-Wilder (2013), reducing anxiety and learning in a positive environment could be especially beneficial in mathematics education.

Gainsburg (2008) and Hodges & Hodge (2017) stress that good mathematics education could be characterised by addressing issues that are relevant to students. A flexible environment and intentional content following FL approaches should be predestined to address topics pertinent to students in education.

2.2. ePortfolios and mathematics education

Using ePortfolios in mathematics education following FL approaches could facilitate that students present and communicate their new competencies as learning artefacts. According to Häcker (2011a), working and learning with (e)portfolios in schools gained acceptance in German-speaking countries in the early 2000s, but has since grown significantly. The definitions of learning using (e)portfolio are as diverse as those of flipped education. We utilise Häcker's definition (2011b) of education utilising (e)portfolio, as following this definition, a portfolio is understood as (a) a targeted collection of artefacts, (b) an independent and autonomous product of the learner, and (c) a self-reflection of the learning process. Utilising ePortfolios in education also changes both teachers' and students' roles and tasks compared to traditional and teacher-driven education. According to Baumgartner & Kalz (2004), when using ePortfolios in education, the teacher should assume both the role of a transfer person and the role of a coach. If there is a synthesis of learning with ePortfolios and education following FL approaches, the transfer role should be taken over by learning materials in a flexible learning environment. Therefore, teachers' main tasks in FL mathematics education using ePortfolios is to be available to students as a coach when students are dealing with meaningful issues. Students' roles in learning with ePortfolios are very similar to students' roles in FL approaches, as learning following FL approaches is based on a new learning culture (from teacher-driven model to student-driven model) and intentional content. If synthesising learning using ePortfolios and education following FL approaches, learning activities could be attributed to *Learning II* or *Learning III* according to Baumgartner & Kalz (2004). *Learning II* is characterised as problem-solving and know-how and *Learning III* as coping with complex situations and knowing-in-action. Problem-solving and dealing with complex situations could also be found in both the learning culture and intentional content of learning bearing FL approaches in mind.

This high level of commonalities and mutual complementary potential of learning with ePortfolios and learning using FL approaches led us to place a synthesis of these two educational approaches at the centre of our educational experiment. When investigating the synthesis of learning utilising ePortfolios and FL approaches in mathematics education, particular attention was paid to our following research question:

How should mathematics learning environments and learning scenarios at a secondary level be designed to achieve a synthesis of ePortfolio work and flipped learning education?

3. Description of our educational experiment

To investigate how a synthesis of ePortfolio work and FL approaches could be established in mathematics education and which design elements should be considered in this synthesis, we conducted an educational experiment with two classes of a secondary level. A total of 41 students were involved in our study for 7 months. The students attended the 9th and 10th grade and were from 14 to 17 years old. Of the authors, one person was involved as a teacher, data collector and researcher in our educational experiment and a second author was involved in data collection and research. Additionally, two other mathematics teachers from the school of our scholarly investigation were involved at times as teachers and at times as observers in our study. One of these teachers knew the classes because she teaches them physics and the second teacher was unfamiliar with the students of our educational experiment. In the course of teaching in our educational experiment, subject areas were covered from the entire curriculum of the 9th and 10th grade. A particular emphasis in the course of our educational investigation was placed on working with functions and trigonometry. A focus on functions and trigonometry is justified by the fact that mathematical modelling should be made more accessible for students. Mathematical modelling should also contribute to facilitating both students' interest in mathematics education and creating concrete learning products.

The characteristic feature of our study was that students utilised intensively educational technologies to deal with the contents taught. Concerning technological hardware, students in our educational experiment could use school computers in the computer lab, their notebooks, tablets and smartphones. Software components of our educational research were GeoGebra and Mahara. The mathematical software package GeoGebra was used by the teacher to provide students with dynamic and interactive learning materials. GeoGebra was also utilised by students to discover the mathematical subject matter and to create digital learning artefacts. In addition to digital learning tools created by the teacher, students could also access other learning materials from the GeoGebra online database in our study. The ePortfolio software Mahara was applied in our research to distribute and share work orders and deadlines as well as to create and share learning artefacts. In our study, the teacher had his Mahara page, and each student had his or her page. The teacher used the page to communicate learning goals and deadlines, and to share materials. Students used their page primarily to present their learning artefacts but also to share information and materials with classmates outside the class.

The interaction of utilising ePortfolios in learning and teaching following FL approaches was investigated in our educational experiment in three design cycles (see Figure 1). A more detailed description of each design cycle can be found in the link below the figure.

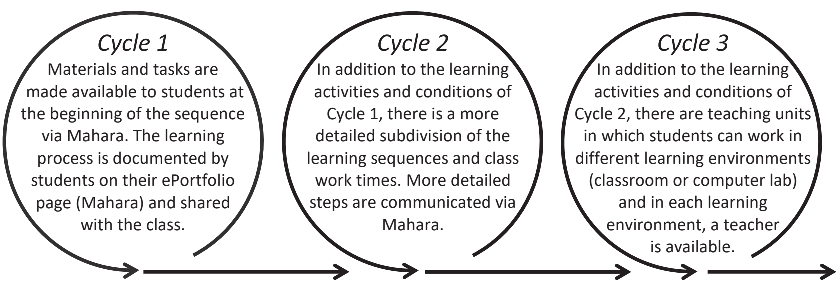

Figure 1: Design cycles of our study; LINK starting with Phase 2

During and after individual design cycles of our educational experiment, we have collected data and information from students and teachers involved and applied a synthesis of design-based research and grounded theory approaches to achieve our research goal.

4. Methods

To explore how mathematics learning environments and scenarios should be designed to synthesise ePortfolio work and FL approaches, we have collected student and teacher data over the entire duration of our educational experiment using written feedback forms as well as individual and group interviews. The resulting data were then evaluated by us applying design-based research and grounded theory approaches.

4.1. Design-based research

Since almost 15 years ago, Reinmann (2005) concluded that educational settings are too complex to create reproducible laboratory conditions and therefore appealed for Design-Based Research (DBR), we also applied DBR approaches in our educational experiment. According to Anderson & Shattuck (2012) and Cobb, Confrey, Disessa, Lehrer, & Schauble (2003), it is characteristic of DBR that real problems are explored in authentic contexts and that there is an interplay between research and practice. DBR is usually triggered by a real problem in an educational setting, followed by a literature-research and interventions based on it. The educational challenge of our study was to explore how to synthesise ePortfolio work and FL approaches in mathematics education at the secondary level. To achieve this aim, several design cycles were applied, incorporating findings and feedback from previous design experiments into the design of later ones. When applying these design cycles, we pursued an explorative interpretation of DBR. In our educational research, we followed Zheng's explanations (2015), according to which several design cycles are necessary to obtain scientific outcomes.

To increase the quality of scientific results, the data of the individual design cycles were also examined following grounded theory approaches.

4.2. Grounded theory approaches

Combining DBR and grounded theory (GT) research approaches should contribute to improving the quality of the findings of our educational experiment concerning a synthesis of ePortfolio work and education following FL approaches. GT research is characterised by many experts (e.g. Charmaz, 2006; Glaser & Strauss, 1999) as a research approach that aims to study real people and their actions in real environments, and thereby gain insights into real and social activities. Furthermore, it is typical for GT research to investigate social and professional networks, and activities of people in these networks (Glaser & Strauss, 1999; Mey & Mruck, 2011). This focus of GT research on real people, real environments, social networks and activities of people in these environments and networks make GT approaches predestined as a research paradigm for our study. Since Breuer, Dieris, & Lettau (2009) emphasised that in GT research, researchers are vital factors and Charmaz (2006) stressed that in GT research it makes a difference who collects data and which tools are used to collect data, we have chosen multiple ways of collecting data in our study. On the one hand, collecting data in our research means that both the teaching and researching author, and the exclusively researching author has collected data. On the other hand, written feedback, and individual and group interviews were conducted to collect data. These approaches to data collection resulted in a total of slightly more than 150 written feedback forms, 17 individual interviews with students, 4 individual interviews with teachers, and 2 group interviews with students from the classes participating in our educational experiment. The research data collected from students was used to develop the categories of this paper and related design development, and the research data collected from teachers was used for design development only.

5. Results

After collecting the research data, we read (feedback) and listened to (interviews) the data several times. This data-skimming should enable us to identify initial topics and patterns in the newly collected data. Then, we completely transcribed the data. Following an interpretative construction of GT research (Charmaz, 2006), we openly coded the data from our educational experiment. Next, we compared and grouped our open codes. By comparing and grouping the open codes, a higher level of abstraction of the data should already be achieved during open coding. This process enabled us to generate a total of 41 open codes in the course of our entire educational experiment. After the open coding process at each data collection cycle, we axially coded all open codes and thereby developed and improved categories. The findings of these categories were then used in theoretical sampling, selective coding, and further development of the design of our study. Finally, the evaluation and analysis of our data following GT and DBR approaches indicated that the following categories would be central for students: (a) task communication and task design, (b) intensity of learning, (c) storage and sharing of knowledge, and (d) usability of the learning environment.

The authors translated the quotations prototypical for the categories from German to English.

5.1. Task communication and task design

Since it is characteristic of both ePortfolio work and FL approaches that education could be characterised as student-driven, students have high decision-making competencies concerning the learning process. On the one hand, this more decision-making competencies are positively evaluated by the students, as it could increase the meaning and enjoyment of mathematics. The following student feedback reflects this increased meaning and enjoyment of mathematics well.

> *It was not only numbers, but one could understand the meaning of the content.*

On the other hand, an increase in decision-making competencies leads to students needing meta-competencies such as time management or discipline when it comes to merging ePortfolio work and FL approaches. If these meta-competencies do not yet exist, synthesising ePortfolio work and FL approaches could lead to an overstrain of students. The following quotation reflects this potential for overtaxing:

> *You had to be strict on yourself in this form of learning […] have discipline*

Following students' feedback, it is clear that students expect support from the teacher:

> *It would be better if the teacher made more pretensions that he organises learning more*

5.2. Intensity of learning

Combining student-driven approaches to learning, such as ePortfolio work and FL approaches, results in students experiencing the learning process as more intense. This increased intensity of learning is experienced and described as positive by most students, as the following student quote shows:

> *Learning was more demanding, but demanding in a good way*

Through an increased intensity and focusing on creating concrete learning products in a synthesis of ePortfolio work and FL approaches, students could identify more with their learning outcomes and be proud of their learning outcomes, as underlined by the following quote:

> *It is exhausting, but at the end when the page is finished, you are always so proud.*

However, to achieve a qualitatively appealing production of concrete learning products and thus a stronger identification and also pride in learning achievements, the students demand appropriate time to deal with the subject matter and creating concrete learning products based on the subject matter. This student desire became evident in many feedbacks, which is why a prototype quote will be presented:

> *Learning was fun, but it would be better if we had more time to do everything properly.*

5.3. Storing and sharing knowledge

When synthesising ePortfolio work and education following FL approaches, students appreciated not only that higher-quality learning products were created, but also that these learning products could be stored and that one could share one's learning products with fellow students and benefit from other students' learning products. By sharing (semi)finished learning products, students indicated that this approach to mathematics learning allowed them to benefit more from their peers' learning outcomes. This benefit from the learning outcomes of fellow students concerns both mathematical and creative competencies of students. A mathematical profiting is reflected in the first quote, and a creative profiting is indicated in the second quote:

> *Through Mahara you also see how others did it, and you can choose the best solution.*

> *Also that you can be inspired by the work of others – how they solved tasks on Mahara.*

However, not only the current learning of mathematics and creating concrete learning products was positively emphasised by students when synthesising ePortfolio work and education bearing FL approaches in mind. Due to the long duration of our educational experiment, the students were also able to experience that self-developed learning products could be reused. This reuse of learning products was positively emphasised by the students, especially during preparations for tests, as the following quote shows:

> *If you learn for a test, you can have a look at your page again. That always helps me.*

Storing of knowledge and competencies were also highlighted by the students looking to the future, speaking for the Matura (school leaving examination), as positive.

5.4. Usability of the learning environment

Linking ePortfolio work and learning following FL approaches in secondary education has also led to increased use of modern technologies. Although the majority of students appreciated using technologies in mathematics education, our educational experiment also identified related challenges. The main topic of this category was the usability of technologies used in our scholarly research. Following students' feedback, it was evident that technologies used should be as easy to operate as possible. An explicit request of the students was that there should be no additional workload by using technologies in mathematics education. The following quote well reflects this request for easy-to-use technologies and no additional workload.

> *Often it takes longer to upload things to the site than to create them. That's annoying.*

However, the usability of the learning environment did affect not only the educational technologies used but also the learning environment in general. The student feedback indicated that when technologies are used in mathematics education, students expect the school learning environment to provide appropriate conditions and opportunities. These conditions and opportunities of the school learning environment are that technologies can also be easily accessed in school. Following student feedback, this access to technologies has affected the school's hardware offerings as well as the ability to use the Internet in an appealing quality for learning at school. These student wishes are reflected, for example, by the following feedback:

> *It would be better if we could go to the computer lab every lesson. Then you could always work at your page [Mahara].*

> *I don't understand why we can't access the WLAN. That would make everything easier.*

Evaluating the student feedback in our educational study highlighted that when designing learning activities where there could be a synthesis of ePortfolio working and learning following FL approaches, it might be vital that task communication and task design is as clear as possible, that due to the increased intensity of learning, appealing time is provided, that students are given sufficient opportunities to store and share knowledge, and that the technological usability of learning settings is given.

6. Discussion, conclusions and further research

By investigating possibilities of synthesising ePortfolio work and FL approaches in mathematics education, and by discovering essential design elements, it became apparent that the following categories are central for students: (a) task communication and design, (b) intensity of learning, (c) storage and sharing of knowledge, and (d) usability of the learning environment. Since our educational study was conducted in secondary education in an urban environment, the categories developed in our research should be relevant to learning mathematics by students in their adolescence primarily. Additionally, as the school of our educational study is located in the city centre of an urban environment, high socio-economic status of students and their parents could be assumed. This high socio-economic status could lead to students in our study being more familiar with using modern technologies and various digital research techniques than the average of students at the same level of education. These favourable conditions for learning in our study should be considered when interpreting the categories of our research.

This multitude of key categories also leads to conclude that when combining ePortfolio work and FL approaches, students' meta-competencies are vital. Since in many cases, it might be that these meta-competencies have to be developed by the students first, it could be reasonable to approach this synthesis slowly. This slow approach is similar to the partial (Burgoyne & Eaton, 2018) or micro (García-Peñalvo, Fidalgo-Blanco, Sein-Echaluce, & Conde, 2016) flipped classroom approach, due to which only some aspects of education are designed following flipped approaches. Learning bearing a synthesis of ePortfolio work and FL approaches in mind could be described as a social activity. Thus, this educational approach is close to mathematics education according to Bell & Pape (2012) and Lee & Johnston-Wilder (2013). According to these authors, learning mathematics could be characterised as a social process. Learning mathematics as a social process means sharing knowledge from individual activities with classmates. Concerning learning mathematics as a social process, the results of our study concretise the description above. It was not a mere sharing of knowledge that supported students when learning but sharing concrete learning products with fellow students. This sharing of learning products should both facilitate mathematics learning and increase creativity. Another finding of our study was that students appreciate using technologies, but technologies should not be used somehow or arbitrarily in teaching and learning. This finding is similar to the explanations given by Orlando & Attard (2016), who stressed that merely using technologies in education is not automatically teaching and learning with technologies. For the students in our study, it was vital that technologies used were easy to operate, that the added value of the benefits of technologies was quickly apparent, and that the learning environment was technology-friendly. However, a technology-friendly learning environment was interpreted much more broadly by the students in our study than the technological equipment of a computer lab. To assess whether a learning environment is technology-friendly, it was essential for students whether in an environment is (good) WLAN (Wireless Local Area Network) access or whether there are enough sockets at different locations in the school building so that one can charge one's own mobile device used for learning at any site. If mathematics education leads to synthesising ePortfolio work and education following approaches, it could be concluded that it is no longer the task of the school to provide technologies, but that the school should not prevent students from using their technologies.

Since our educational study in an urban secondary school aimed to explore how learning environments and scenarios should be designed to achieve a synthesis of ePortfolio work and learning mathematics following flipped learning approaches, our further research should expand research perspectives. On the one hand, the quality of the results should be improved by expanding the field of research. Expanding the research field means that schools from non-urban areas should also be included in our further studies. Likewise, our research results could be improved if students from lower secondary schools would be involved in further research. On the other hand, expanding the research methodology could improve the quality of the results of our study. Expanding the research methodology would mean that, in addition to qualitative research approaches, quantitative approaches would also be included in our further research. By using quantitative research techniques, it should be possible to examine the validity of the categories developed.

References

Anderson, T., & Shattuck, J. 2012. Design-Based Research. Educational Researcher, 41, 16–25.

Baumgartner, P., & Kalz, M. 2004. Content Management Systeme für den Bildungsbereich. In Baumgartner, P., Häfele, H. und Maier-Häfele K: Content-Management-Systeme in e-Education: Auswahl, Potenziale und Einsatzmöglichkeiten. Innsbruck; Wien; München; Bozen.

Bell, C. V., & Pape, S. J. 2012. Scaffolding students' opportunities to learn mathematics through social interactions. Mathematics Education Research Journal, 24(4), 423–445.

Breuer, F., Dieris, B., & Lettau, A. 2009. Reflexive Grounded Theory: Eine Einführung für die Forschungspraxis (2009th ed.). Wiesbaden: VS Verlag für Sozialwissenschaften.

Burgoyne, S., & Eaton, J. 2018. The Partially Flipped Classroom:The Effects of Flipping a Module on "Junk Science" in a Large Methods Course. Teaching of Psychology, 45(2), 154–157.

Burton, L. 2004. "Confidence is Everything" – Perspectives of Teachers and Students on Learning Mathematics. Journal of Mathematics Teacher Education, 7(4), 357–381.

Chao, T., Chen, J., Star, J. R., & Dede, C. 2016. Using Digital Resources for Motivation and Engagement in Learning Mathematics: Reflections from Teachers and Students. Digital Experiences in Mathematics Education, 2(3), 253–277. https://doi.org/10.1007/s40751-016-0024-6

Charmaz, K. 2006. Constructing Grounded Theory: A Practical Guide through Qualitative Analysis (1 edition). London ; Thousand Oaks, Calif: SAGE Publications Ltd.

Cobb, P., Confrey, J., Disessa, A., Lehrer, R., & Schauble, L. 2003. Design Experiments in Educational Research. Educational Researcher, 32, 9–13.

Enfield, J. 2016. The Value of Using an E-Text in a Flipped Course. TechTrends, 60(5), 449–455.

Esperanza, P., Fabian, K., & Toto, C. 2016. Flipped Classroom Model: Effects on Performance, Attitudes and Perceptions in High School Algebra. In K. Verbert, M. Sharples, & T. Klobučar (Eds.), Adaptive and Adaptable Learning: 11th European Conference on Technology Enhanced Learning, 85–97.

Flipped Learning Network (FLN). 2014. The Four Pillars of F-L-I-P. Retrieved from https://flippedlearning.org/definition

Fogarty, G., Cretchley, P., Harman, C., Ellerton, N., & Konki, N. 2001. Validation of a questionnaire to measure mathematics confidence, computer confidence, and attitudes towards the use of technology for learning mathematics. Mathematics Education Research Journal, 13(2), 154–160.

Gainsburg, J. 2008. Real-world connections in secondary mathematics teaching. Journal of Mathematics Teacher Education, 11(3), 199–219. https://doi.org/10.1007/s10857-007-9070-8

García-Peñalvo, F. J., Fidalgo-Blanco, Á., Sein-Echaluce, M. L., & Conde, M. Á. 2016. Cooperative Micro Flip Teaching. In P. Zaphiris & A. Ioannou (Eds.), Learning and Collaboration Technologies: Third International Conference, LCT 2016, Held as Part of HCI International 2016, Toronto, ON, 2016, Proceedings (pp. 14–24).

Glaser, B. G., & Strauss, A. L. 1999. Discovery of Grounded Theory: Strategies for Qualitative Research. New Brunswick: AldineTransaction.

Häcker, Th. 2011a. Vielfalt der Portfoliobegriffe. Annäherung an ein schwer fassbares Konzept. In Brunner, I., Häcker, Th., Winter, F. (Hrsg.) Das Handbuch Portfolioarbeit. Konzepte – Anregungen – Erfahrungen aus Schule und Lehrerbildung. Seelze-Velber.

Häcker, Th. 2011b. Wurzeln der Portfolioarbeit - Woraus das Konzept erwachsen ist. In Brunner, I., Häcker, Th., Winter, F. (Hrsg.) Das Handbuch Portfolioarbeit. Konzepte – Anregungen – Erfahrungen aus Schule und Lehrerbildung. Seelze-Velber.

Hodges, T. E., & Hodge, L. L. 2017. Unpacking personal identities for teaching mathematics within the context of prospective teacher education. Journal of Mathematics Teacher Education, 20(2), 101–118.

Hung, C.-M., Huang, I., & Hwang, G.-J. 2014. Effects of digital game-based learning on students' self-efficacy, motivation,

anxiety, and achievements in learning mathematics. Journal of Computers in Education, 1(2), 151–166. https://doi.org/10.1007/s40692-014-0008-8
Krathwohl, D. R. 2002. A revision of Bloom's taxonomy: An overview. Theory into Practice, 41(4), 212–218.
Lee, C., & Johnston-Wilder, S. 2013. Learning mathematics—letting the pupils have their say. Educational Studies in Mathematics, 83(2), 163–180. https://doi.org/10.1007/s10649-012-9445-3
Mey, G., & Mruck, K. 2011. Grounded Theory Reader (2nd ed.). Wiesbaden: VS Verlag für Sozialwissenschaften.
Muir, T., & Geiger, V. 2016. The affordances of using a flipped classroom approach in the teaching of mathematics: a case study of a grade 10 mathematics class. Mathematics Education Research Journal, 28(1), 149–171. https://doi.org/10.1007/s13394-015-0165-8
O'Flaherty, J., & Phillips, C. 2015. The use of flipped classrooms in higher education: A scoping review. The Internet and Higher Education, 25, 85–95.
Orlando, J., & Attard, C. 2016. Digital natives come of age: the reality of today's early career teachers using mobile devices to teach mathematics. Mathematics Education Research Journal, 28(1), 107–121.
Reinmann, G. 2005. Innovation ohne Forschung? Ein Plädoyer für den Design-Based Research-Ansatz in der Lehr-Lernforschung. Unterrichtswissenschaft, 33(1), 52–69.
Samuelsson, J. 2006. ICT as a Change Agent of Mathematics Teaching in Swedish Secondary School. Education and Information Technologies, 11(1), 71–81. https://doi.org/10.1007/s10639-005-5713-5
Wasserman, N. H., Quint, C., Norris, S. A., & Carr, T. 2015. Exploring Flipped Classroom Instruction in Calculus III. International Journal of Science and Mathematics Education, 1–24.
Wolff, L.-C., & Chan, J. 2016. Defining Flipped Classrooms. In L.-C. Wolff & J. Chan (Eds.), Flipped Classrooms for Legal Education, 9–13. https://doi.org/10.1007/978-981-10-0479-7_2

Zheng, L. 2015. A systematic literature review of design-based research from 2004 to 2013. Journal of Computers in Education, 2(4), 399–420. https://doi.org/10.1007/s40692-015-0036-z

Enhancing education and training through data-driven adaptable games in flipped classrooms

Muriel Algayres[1], Yash Shekhawat[2], Olga Timcenko[1], Maria Zotou[3], Efthimios Tambouris[3], Christos Malliarakis[4], Eleni Dermentzi[5], Roberto Lopez[6], Eirik Jatten[7] and Konstantinos Tarabanis[3]

1 Aalborg University, Denmark, mgal@create.aau.dk, ot@create.aau.dk;
2 Nurogames GmbH, Germany, yash.shekhawat@nurogames.com;
3 University of Macedonia, Greece, mzotou@uom.edu.gr, tambouris@uom.edu.gr, kat@uom.edu.gr;
4 Ekpaideftiria E. Mantoulidi SA, Greece, malliarakis@gmail.com;
5 Northumbria University, United Kingdom, eleni.dermentzi@northumbria.ac.uk;
6 Artificial Intelligence Techniques, Spain, robertolopez@artelnics.com;
7 Revheim Skole, Stavanger Kommune, Norway, eirik.jatten@stavanger.kommune.no

Abstract

The Flipped Classroom (FC) is a set of pedagogical approaches that move the information transmission out of class and exploit class time for active and/or peer learning activities. In this context, students are required to engage with pre- and/or post-class activities in order to prepare themselves for class work. The FC instruction method has already been used in conjunction with other learning strategies. This theoretical paper presents the first developmental steps of a research project, which aims at building the FC through a fully bespoke and personalized experience, by using data-driven adaptable games and problem-based learning elements to improve the learning experience. The project will develop a gaming platform that will support the whole FC in a cyclical perspective, and aims to use the resources of gamification in a more significant manner that could go beyond score tracking and badges. Moreover, the problem-based learning approach will be used to better frame the learning activities included in FCs, while learning analytics features will provide adaptable learning pathways. The potential of this approach is to build a better FC experience for all the stakeholders. Students will be given more agency to calibrate their learning experience, while educators can monitor the students' progress more effectively and adjust their learning activities accordingly. Finally, researchers will get better insight into the FC learning process, and the mechanics, which contribute to optimize the learning experience.

Keywords: flipped classroom, serious games, problem-based learning, learning analytics

1. Introduction

Active learning is now a staple of education, aiming at fostering 21st century skills. Among active learning methods, the most prevalent in education is the Flipped Classroom (FC), which is a set of pedagogical approaches that: " 1. move most information-transmission teaching out of class; 2. use class time for learning activities that are active and social; and 3. require students to complete pre- and/or post-class activities to fully benefit from in-class work." (Abeysekera & Dawson, 2015, p. 6).

The efficiency of the FC to support students' motivation and self-directed learning has been largely documented in literature reviews (e.g. O'Flaherty & Phillips, 2015), and the method is credited with success in improving students' communication skills and independent learning (Lo & Hew, 2017). Further research now investigates the potential of the FC used in conjunction with other learning methodologies, such as Game-Based Learning (GBL) and elements from Problem-Based Learning (PBL) (Klemke et al., 2018), in order to better structure out-of-class and in-class activities, increase student engagement and motivation, and better monitor student progress in FCs.

The FLIP2G project (http://flip2g-project.eu/) aims to establish a knowledge alliance between higher education institutions, schools and private companies, which will develop a new pedagogical method that combines PBL and FC with GBL. This method will be implemented as a simulation-based serious game platform that will support PBL-enhanced flipped classroom processes, adaptive pathways and educational data recording. The platform will also employ Learning Analytics (LA) features that will produce informative insights on learning process by analysing the gathered educational data. The above results aim to produce an engaging pedagogical model that employs novel technologies to foster motivation and skills development, generate adaptive learning pathways, and allow self-directed learning in education and training.

The purpose of this paper is to present the first outcomes of the FLIP2G project, namely a pedagogical model for integrating PBL with the FC instruction method, and a study on elements from serious games that can be applied in FCs. Finally, we conclude with a discussion on upcoming project outputs and milestones.

2. Background

3.1. Learning in the FC

Lage et al. defined the FC in these terms: "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" (Lage et al. 2000). The FC tends to be represented as a linear process following these three phases: during the pre-class time the students prepare for the lesson, in-class they engage in group activities or discussion, and after class they complete their assignments or extend their learning. The FC presents a very specific form of didactic contract (Brousseau, 1998), in which the process of institutionalization of knowledge is self-directed by the students themselves.

However, for the purpose of a more holistic view on learning in the FC, the circular model proposed by Gerstein (2011) appears more relevant because it divides the different phases in FCs based on their pedagogical objectives rather than their chronological order. Figure 1 presents this structure.

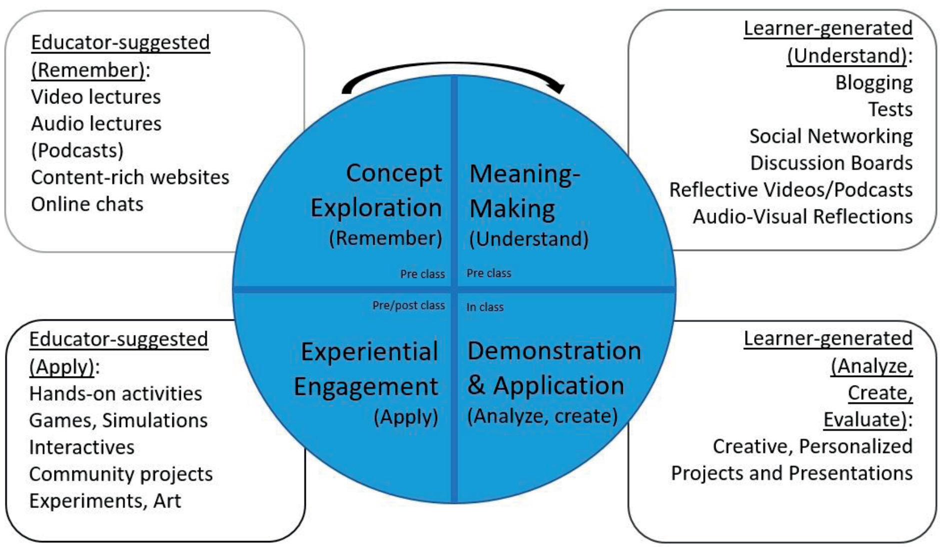

Figure 1: The Flipped Classroom Model as presented by (Gerstein, 2011).

The process begins with concept exploration. This model appears more efficient to study the FC and integrate other pedagogical tools to its implantation, as it approaches learning as a cycle and not simply a linear process. As such, the experiential engagement and concept exploration phase can overlap between the end of a FC cycle and the beginning of the next. Approaching the FC as a cycle rather than a linear process offers better perspectives to regulate its potential for self-directed learning and to integrate other methodologies in the process.

2.2. PBL and the FC

Problem-based learning (PBL) is a staple of active learning (Barge, 2010). The steps included in PBL are as follows: learners are given an ill-defined problem and they are tasked with formulating it to a concrete problem to solve. The next step is the formulation of tasks that will lead to problem solving, which should require all members to use their own knowledge and skills. Problem analysis follows, in which learners gather data to solve the problem. Once the problem has been analysed and a suitable solution devised, the learners take steps to solve the problem (Barge, 2010).

Research into blending PBL and the FC has been carried out successfully by designing learning activities in Virtual Learning Environments (VLEs), like Moodle (e.g. Triantafyllou, 2015).However, while PBL activities have been used in the FC, its integration was usually limited as an in-class activity. Clark (2015) for example used the FC methodology in secondary education as a means to support students' engagement in problem-solving activities in-class. Therefore, we believe that further application of the complete PBL model in the FC has the potential to support learning approaches through a more bespoke experience.

2.3. Learning Analytics in the FC

Another tool that has been employed for further improving FCs is the use of Learning Analytics (LA). "LA is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs." (Long & Siemens, 2011). Integration of LA in the FC goes beyond using data to evaluate the students learning process in a more reliable process compared to unreliable self-reported learning strategies (Jamieson-Noel & Winne, 2002). The purpose of LA is twofold: they are meant to support the learners learning process, but also to allow educators and researchers to intervene and modify the learner experience as needed. The goal with such interventions is to offer smart learning environments that support a fully integrated and personalized learning experience. According to Chen et al. (2016, p. 566), "…through big data and learning analytics, smart learning environments could derive new and more effective learning models by analysing the data collections of various learners and further extract valuable learning patterns, to provide suggestions and recommendations to the learners over long periods of time, possibly even during their future careers". Therefore, extensive integration of LA in the FC has the potential of reinforcing the FC methodology in the sensitive parts of the learning process, such as sustained engagement in the pre-class process, or supported self-regulated learning in the post-class phase (Herreid & Schiller, 2013).

2.4. Game-Based Learning (GBL) in the FC

Use of games in the FC

There are many precedents for effective use of Game-Based Learning (GBL) in the FC. Serious games have commonly been used during the in-class phase of the FC to engage students in active learning or collective activities. Games used for computer education and coding practice, such as HackerRank and CodinGame, are examples of this approach (Bye, 2017). Similarly, Cukurbasi and Kiyici (2018) used a combination of FC and LEGO applications to develop a mathematic algorithm instruction curriculum for the secondary school.

Serious games have also been used to support students' engagement with the learning material, and help students to practice before class. For example, *The Protégé* lets the students scaffold their engagement with the pre-class reading material by having them play as investigators in a library (Ling, 2018).

Finally, in the post-class phase, gamification appears as a common tool to calibrate the learning experience. Gamification is defined as an "…umbrella term for the use of video game elements to improve user experience and user engagement in non-game services and applications" (Deterding, 2011) and is different to GBL, which is the inclusion of games of the development of skills or training. VLEs often rely on such gaming elements (e.g. scores, levels and badges) to help students visualize their progression. Although gamification needs to be developed beyond the superficial integration of rewards-based mechanics (Becker & Nicholson, 2016), it remains a useful tool to calibrate the learning experience in the post-class phase.

Gaming Elements in the FC

Current serious games give us insights into the potential of integrating gaming elements in the FC, and the gaming elements requirements for the FC. Many games possess a component of PBL or situated learning. For example, Foldit is a game in which players can learn about protein folding and discovery of new proteins through problem-solving on the game platform (https://fold.it/portal/). Their experience is supported by rewards-based game mechanics such as leaderboards, points score, and level-up. The game Sharkworld, which supports learning of project management principles, appears also very problem-based as players are introduced to a real-world project management problems that the players have to solve by themselves (http://www.sharkworldgame.com/). The game similarly introduces rewards-based mechanics as score tabs and level-ups, and the level system is designated to frame the learning experience. Finally, the game SimPort also proposes a problem-based approach that relies on collaborative work, with each player being a team member in a construction project (Warmerdam et al., 2007). Simulation games in that regard offer great potential to support PBL applications in the FC. Moreover, Deshpande and Huang (2011) suggest through an extended state-of-the-art review that proper application of simulation games in engineering education has the potential to maximize the learning outcome, and transferability of academic knowledge to the industry. Therefore, such games may support the development of entrepreneurship skills within FC for education and training.

Furthermore, serious games rely heavily on a positive feedback loop, which supports learning through trial and error. This feature follows the gameplay model of “Objective-Challenge-Reward” (OCR) as formulated by Albina (2010). In this model, the objective needs to be clearly defined, with a clear communication regarding the conditions of success. Actions have also to be adapted to the player’s level, neither too easy nor too difficult, and feedback needs to indicate clearly why the challenge was a success or a failure, so that the player can adjust their actions afterwards. Foldit, already mentioned, uses the positive feedback loop mechanic since success is built progressively, so trial and error is a viable strategy. Democracy (http://www.positech.co.uk/democracy/), a political game where the player’s goal is to become President of the United States, also uses this mechanics. In this game, positive and negative decisions have a direct impact on the player’s score. Players can therefore adjust their strategy in real time and experiment around potentially winning strategies. Finally, the Mathis is project (http://mathisis-project.eu/), a math puzzle game for children, shows how LA can be used to feed the positive feedback loop since the game difficulty is automatically adjusted to the player’s level. Thus, the player progresses gradually and can try out different strategies to solve the puzzle and progress.

Finally, games can employ different strategies to present the players with the rules and mechanics. Within the context of the FC, guided learning could be employed to introduce learners to background knowledge. Guided learning means that the rules of the games are embedded in the play experience, usually in the form of tutorials, or that the experience is supervised by the educator. Foldit again provides an example of this approach. The game possesses extensive tutorials that explains the game mechanic and scientific principles in increasing complexity. However, some games rely more on learning by doing and anchored instruction, meaning that the players need to figure out the principles of the game as they go along, usually through trial and error. For example in the game Lightbot (https://lightbot.com/), a coding robotics game, players have to complete a series of tasks with almost no instruction for the game. They can only reach the next level by figuring out which fragments of code they need to use to get the robot to perform a specific task. Thus, although serious games can present a number of design choices and features, some gaming elements appear especially useful to implement GBL in the FC, especially the positive feedback loop and problem-solving tasks.

3. Presentation of the theoretical model

The FLIP2G project endeavours to develop a theoretical model that will combine PBL elements, LA and GBL in the FC. Our objective is to develop a gaming platform that will allow students to undergo a personalized self-regulated learning experience, and facilitate the work of educators by providing them with an accessible interface and data to support calibration of the curriculum. To develop this model, we have taken the FC cycle by Gerstein (2011) as a foundation stone, and integrated the aforementioned approaches. This model consists of three levels to the learning experience: the learning activities, data generation, and LA. Figure 2 illustrates this three-tier model.

On the first level, learning designers develop specific activities. These activities are framed by the PBL pedagogy and may be game-based learning activities or contain gamification elements. Such activities are developed in "plan-design-implement" cycles, and may be adjusted based on the findings produced on the LA level (third level of the model).

On the second level of the model, the designed learning activities are applied and implemented in consecutive FC cycles. Each phase in such cycles generates its own data in online environments through students' engagement with the online resources, online exchanges and productions.

On the third level, educational data produced on the second level is processed through LA to provide formative and summative feedback to students and educators, and allow educators to adjust the learning process and the curriculum.

The following sections will present an overview of each step of this new FC cycle on the second level of the model.

3.1. The experiential engagement phase

The experiential engagement represents both the conclusion of a FC circle and the introduction of the next one. During this phase, students can engage in online discussions, play a video game in pairs, or complete their learning by out-of-doors activities, e.g. visiting a museum. For a PBL approach, students can be introduced to an ill-defined problem through video lectures and tutorial. In the final phase of the PBL, this phase will also be when students evaluate a solution to the problem by running experiments and surveys.

3.2. The concept exploration phase

This phase is when the students start engaging with learning materials. From a PBL perspective, this is when students groups try to understand and analyze the problem. They can build their knowledge by classic means of video lectures, podcasts, and textbooks or by discussing with their teachers. During this phase, the use of games can be a very efficient means to engage with the problem, e.g. with historical or simulation games. Engagement with learning material during the concept exploration phase can be supported by peer learning activities such as discussions, debates and concept mapping activities.

3.3. The meaning making phase

The meaning making phase is the phase of problem analysis for a PBL approach. This phase is supported by hands-on activities and summative assessments: discussions in class, writing essays and reports, develop wikis or online material.

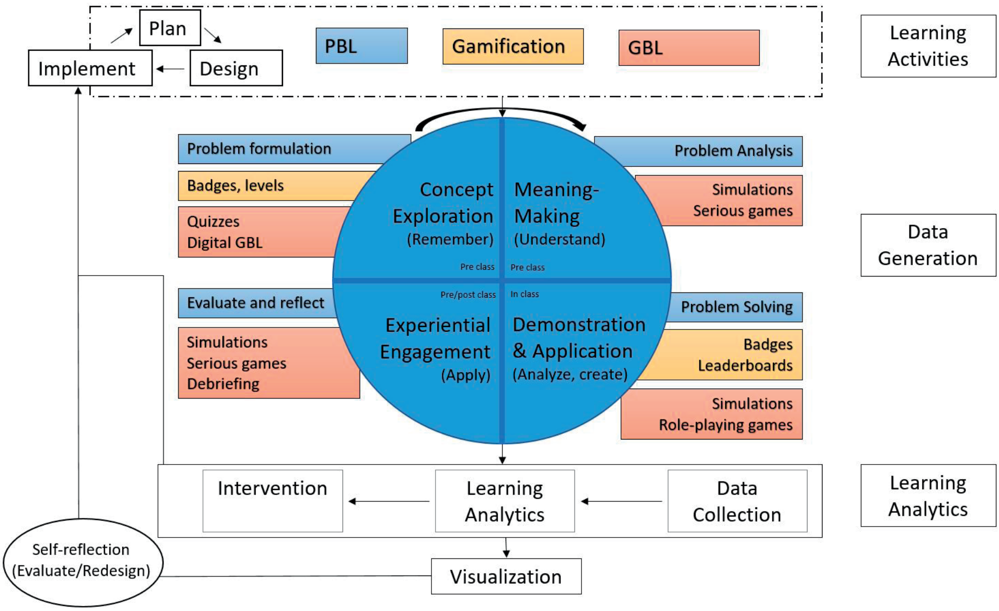

Figure 2: The proposed three-tier educational model

3.4. The demonstration and application phase

Finally, the demonstration and application phase is when students design and implement a solution for a PBL activity. They can work online or offline, as a whole group or in smaller units, each working separately before bringing all elements of a solution together. Students can also design their own online portfolio and build on social interactions and exchanges online.

4. Future Development

In the previous section, we presented a pedagogical model applying the PBL approach to the FC learning cycle in order to better frame and design learning activities for FCs. Moreover, this model takes into consideration the integration of game-based learning and serious games elements in order to support skill development and motivation in FC. Finally, the model accommodates the use of LA in order to provide data-driven and adaptable learning pathways for learners in FCs.

As a first step, we have investigated current serious games in order to identify which gaming elements could be integrated in PBL-led FCs. The next step will be now to develop a simulation-based serious game platform, which will support PBL-enhanced flipped classroom processes, adaptive pathways, and educational data recording. This platform is going to be employed and evaluated for designing and implementing learning modules on secondary and higher education and in training. For developing such modules, we are going to apply a learning design approach with the aim to produce learning scenarios that can be transferred to various contexts.

A major part of the future development in the project is the LA features that the game platform is going to employ. The next milestone in this regard will be a detailed description of possible learning activities in each phase of the FC, the data that can be produced during these activities, and the LA that will be applied in such data in order to produce informative insights on learning processes. Such insights will be then used to adapt pathways in order to adjust learning to individuals, and also to provide formative and summative feedback to learners and educators. The educators will then be able to use this feedback to adjust and redesign learning activities in order to better facilitate their teaching.

5. Conclusion

We have seen that the FC has already been used in conjunction with other learning strategies. GBL and simulations have been used in the FC with efficiency, but usually at a targeted time of the FC process, either for pre-class preparation or as an in-class activity. Some elements of PBL (especially for problem formulation and problem-solving activities) have been found in the FC as well. Furthermore, while the educational potential of LA is also established, its complete integration through smart learning environments is still an expanding field.

Our model aims at building the FC through a fully bespoke and personalized experience, by using various tools to improve the learning experience. It aims at building a gaming platform that swill support the whole FC in a cyclical perspective, rather than using games in a punctual manner. Similarly, such a platform could use the resources of gamification in a more significant manner that could go beyond score tracking and badges.

The potential of this model is to build a better FC experience for all the stakeholders. Students are given more agency to calibrate their learning experience. Educators can monitor the students' process more effectively and adjust their learning activities accordingly. And finally, researchers will get better insight into the FC learning process and the mechanics which contribute to optimize the learning experience.

6. Acknowledgements

This research was conducted in the context of the FLIP2G project. This project has been funded with the support of the Erasmus+ programme of the European Union. This paper reflects the views only of the authors, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

References

Abeysekera, L., & Dawson, P. 2015. Motivation and cognitive load in the flipped classroom: Definition, rationale and a call for research. Higher Education Research & Development, 34(1), 1-14.

Albinet, M. 2010. Concevoir un jeu vidéo. Tout ce que vous devez savoir pour élaborer un jeu vidéo (1er ed.). Limoges: FYP éditions.

Barge, S. 2010. Principles of problem and project learning, the Aalborg PBL model. Aalborg: Aalborg University. DOI:http://www.aau.dk/digitalAssets/62/62747_pbl_aalborg_modellen.pdf

Becker, K., & Nicholson, S. 2016. Gamification in the classroom: old wine in new badges. In Schrier, K. (2016). Learning, Education and Games. Volume Two: Bringing Games into Educational Contexts. ETC Press, Carnegie Mellon University, USA, p. 61-86.

Bye, R. T. 2017. A Flipped Classroom Approach for Teaching a Master's Course on Artificial Intelligence. In International Conference on Computer Supported Education (pp. 246-276). Springer, Cham.

Brousseau G. 1998. Théorie des situations didactiques: Didactique des mathématiques 1970-1990. Grenoble: La Pensée Sauvage.

Chen, N. S., Cheng, I. L., & Chew, S. W. 2016. Evolution is not enough: Revolutionizing current learning environments to smart learning environments. International Journal of Artificial Intelligence in Education, 26(2), 561-581.

Clark, K. R. 2015. The effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom. Journal of Educators Online, 12(1), 91-115.

Cukurbasi, B., & Kiyici, M. 2018. High school students' views on the PBL activities supported via flipped classroom and LEGO practices. Journal of Educational Technology & Society, 21(2), 46-61.

Deshpande, A. A., & Huang, S. H. 2011. Simulation games in engineering education: A state-of-the-art review. Computer applications in engineering education, 19(3), 399-410.

Deterding, S., Dixon, D., Khaled, R., Nacke, L. 2011. From game design elements to gamefulness: Defining "gamification". Proceedings of the 15th International Academic MindTrek Conference (9–15). New-York : ACM.

Gerstein, J. 2011. The flipped classroom: a full picture, User Generated Education, available at:
http://usergeneratededucation.wordpress.com/2011/06/13/the-flipped-classroom-model-afull-picture/

Herreid, C. F., & Schiller, N. A. 2013. Case studies and the flipped classroom. Journal of College Science Teaching, 42(5), 62-66.

Jamieson-Noel, D., & Winne, P. H. 2002. Exploring students' calibration of self-reports about study tactics and achievement. Contemporary Educational Psychology, 27(4), 551-551-572.

Klemke, R., Eradze, M., & Antonaci, A. 2018. The flipped MOOC: using gamification and learning analytics in MOOC design – a conceptual approach. Education Sciences, 8(1), 25.

Lage, M. J., Platt, G. J., & Treglia, M. 2000. Inverting the classroom: A gateway to creating an inclusive learning environment. The Journal of Economic Education, 31(1), 30-43.

Ling, L. T. Y. 2018. Meaningful Gamification and Students' Motivation: A Strategy for Scaffolding Reading Material. Online Learning, 22(2), 141-155.

Lo, C. K., & Hew, K. F. 2017. A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. Research and Practice in Technology Enhanced Learning, 12(1), 4.

Long, P. and Siemens, G. 2011. Penetrating the fog: analytics in learning and education. Educause Review Online 46 (5): 31-40.

O'Flaherty, J., & Phillips, C. 2015. The use of flipped classrooms in higher education: A scoping review. The internet and higher education, 25, 85-95.

Triantafyllou, E. 2015. The flipped classroom: Design considerations and moodle. In Using Moodle for supporting flipped classrooms, Ingeniør Uddannelsernes Pædagogiske Netværk, IUPN, pp. 5-12

Warmerdam, J., Knepflé, M., Bekebrede, G., Mayer, I. and Bidarra, R., 2007. The serious game simport: Overcoming technical hurdles in educational gaming. Learning with games 2007, pp. 307-314.